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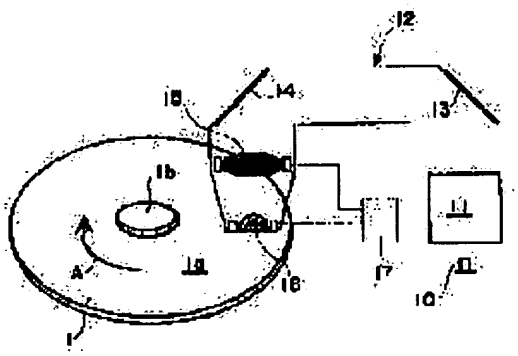
(54) OPTICAL RECORDING AND REPRODUCING SOLID IMMERSION LENS AND OPTICAL RECORDING AND REPRODUCING DEVICE

(57)Abstract:

PROBLEM TO BE SOLVED: To provide a optical recording/reproducing device capable of high density optical recording/reproducing and a solid immersion lens suited to it.



SOLUTION: This device is provided with a laser beam source 10 generating a laser beam of at least partial wavelength range of wavelength 350 nm to 700 nm, an objective lens 15 arranged close to a surface recording face 1a of a magneto-optical disk 1 and condenses the light from the laser beam source, a solid immersion lens 16 receiving laser luminous flux from this objective lens and forming a recording/reproducing condensing spot on the recording face, a motor rotating the magneto-optical disk 1 and a movable optical system 12 scan moving the solid immersion lens in the radial direction in the state approaching the solid immersion lens to the recording face of the rotating magneto-optical disk. At this time, the solid immersion lens 16 is formed from the material having a refractive index for the laser beam from the laser beam source 10 becomes 2.0 or above.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention relates to the equipment which performs information record and playback to record media, such as an optical disk, using a laser beam, especially the optical record regenerative apparatus which approaches a record medium and comes to arrange a solid immersion lens.

[0002]
[Description of the Prior Art] In recent years, the play back system which makes effectual numerical aperture of optical system one or more using a solid immersion lens (called a solid emersion lens or SIL) in the equipment which carries out record playback of the information optically or a system especially a magneto-optic-recording regenerative apparatus, or a system for the purpose of raising recording density is proposed.
[0003] An example of such an optical record regenerative apparatus is shown in drawing 13 , and it becomes the parallel flux of light within the fixed optical system 902, and the laser beam (wavelength of 650nm) injected from semiconductor laser 901 changes a direction by the mirror 904,905 within the movable optical system 903, is led to an objective lens 906, turns into light which condenses toward the solid immersion lens 907 made from semi-sphere-like glass (refractive index 1.5), and forms a spot in the lens base of a solid immersion lens 907. Contiguity arrangement of the base of a solid immersion lens 907 is carried out on the front face of the optical record medium (for example, magneto-optic disk) 910, and the front face of the optical record medium 910 is approaching to the approaching space field at the base of a lens of a solid immersion lens 907, and forms a condensing spot in a recording surface using the transmitted light and effusion light (EBANESSENTO light) of a solid immersion lens 907.
[0004] It is in the condition of carrying out high-speed rotation of the optical record medium 910 on the occasion of record playback of the information by this equipment, and the condensing spot formed in the front face of the optical record medium 910 performs record playback of the optical information on high density, making radial carry out scan migration of the solid immersion lens 907 according to the movable optical system 903, and adding a focus servo according to an objective lens 906 and a control system 908. Thus, the diameter of a condensing spot formed is decided by numerical-aperture N=n-sintheta (however, the refractive index of the n:solid immersion lens 907, theta: include angle which carries out incidence to a solid immersion lens) of a solid immersion lens 907, and wavelength lambda, and is lambda/(n-sintheta) mostly.
[0005]
[Problem(s) to be Solved by the Invention] In such an optical record regenerative apparatus, although the demand which makes the diameter of a condensing spot as small as possible, and raises recording density is strong, it is so desirable that wavelength lambda is so short that the refractive index n of a solid immersion lens is large in order to make the diameter of a condensing spot small so that the above-mentioned relation may show. Here, there is a limitation in short wavelength-ization of a laser beam, and when using semiconductor laser especially as a laser light source, although it is a red field

(wavelength of 600-700nm), by current, it is thought that a blue field (wavelength of 350-550nm) is also a minimum in the future. However, it was very difficult to enlarge a refractive index to the light of such short wavelength in the case of a glass ingredient.
[0006] This invention is what took the example by such situation, and it aims at forming a condensing spot smaller than before using a solid immersion lens, and offering the optical record regenerative apparatus in which optical record playback of high density is possible, and offering the solid immersion lens suitable for such equipment.
[0007]
[Means for Solving the Problem] For such purpose achievement, the solid immersion lens concerning this invention is made from the ingredient with which the refractive index to the light of some [with a wavelength of 350nm - 700nm / at least] wavelength range becomes 2.0 or more, and it is used in order to condense the light of some [this / at least] wavelength range and to make the condensing spot for optical record playback form. In addition, as an ingredient suitable for forming such a solid immersion lens, there are a diamond, strontium titanate, silicon carbide, a rutile, gallium phosphide, zinc sulfide, an arsenic sulfide, lithium niobate, a zirconium dioxide, silicon nitride, etc.
[0008] Moreover, the laser light source which the optical record regenerative apparatus concerning this invention makes generate the laser beam of some [with a wavelength of 350nm - 700nm / at least] wavelength range, The solid immersion lens in which are arranged in, and it is condensed and the condensing spot for record playback is made to approach on the surface of a record medium, and to form in response to the laser beam bundle which carries out incidence on the surface of a record medium (for example, magneto-optic disk) from a laser light source, The scan drive which makes the scan migration of the solid immersion lens carry out in the flat-surface movement direction and the different direction in the medium drive to which flat-surface movement (rotation) of the record medium is carried out, and the condition of having made the solid immersion lens approaching the front face of the record medium which is carrying out flat-surface movement (For example, head arm equipment) It has, and it is constituted and the solid immersion lens is made from the ingredient with which the refractive index to the laser beam from a laser light source becomes 2.0 or more.
[0009] Thus, in this invention, the ingredient of a solid immersion lens and the laser beam condensed by this solid immersion lens are chosen suitably, and a solid immersion lens and a laser beam are used under the combination of the conditions from which a refractive index becomes 2.0 or more. For this reason, a solid immersion lens is used with a big refractive index, a condensing spot is made small, and record playback of the information on high density is attained.
[0010] In addition, it is desirable to constitute so that it may be put on the recording surface of the record medium which is carrying out flat-surface movement with the medium drive, an optical record regenerative apparatus can be constituted using the slider which surfaces from this recording surface by air bearing, and is located, a solid immersion lens may be arranged by the slider in this case and scan migration of the slider may be carried out by the scan drive. If it does in this way, in order that a slider may always maintain a fixed distance by air bearing and may surface from a recording surface, the focal device of a lens becomes unnecessary. Moreover, the objective lens which a slider is made to condense the laser beam bundle from a laser light source, and is made to irradiate a solid immersion lens can be prepared, and a configuration can be simplified.
[0011] Moreover, it is desirable to form the jogging actuator which makes the minute migration of the slider carry out in the scan migration direction and this direction in a scan drive. Thereby, in a scan drive, control performs difficult fine tracking control and the higher-density and highly precise record playback of it is attained.
[0012] The optical prism or optical mirror for reflecting the laser beam from a laser light source in a slider, and leading to an objective lens can be prepared. In this case, it is desirable to form the jogging actuator which tunes the inclination of the reflector of an optical prism or an optical mirror finely. Thereby, the degree of freedom of optical system becomes high, and it becomes possible in highly precise tracking control with a jogging actuator.
[0013] The component which has the giant magneto-resistance or the magneto-resistive effect for

playback to a slider may be prepared, and the equipment which is a small compact and can perform highly precise playback by this can be obtained. Moreover, may prepare coiled form conductive wiring in the location which counters the record medium in a slider, this conductive wiring is made to perform the field modulation of a record medium, and over-writing of record is attained.
[0014]
[Embodiment of the Invention] Hereafter, the desirable operation gestalt of this invention is explained with reference to a drawing. The 1st operation gestalt of the optical record regenerative apparatus concerning this invention is shown in drawing 1 , a laser beam with a wavelength of about 650nm is irradiated toward the fixed optical system 11 from semiconductor laser 10, in the fixed optical system 11, it becomes the parallel flux of light, and the 1st mirror 13 within the movable optical system 12 irradiates. Thus, the irradiated laser beam can change a direction by the 1st and 2nd mirrors 13 and 14 in the movable optical system 12, is led to an objective lens 15, turns into light which condenses toward the solid immersion lens 16 made from semi-sphere-like silicon carbide (SiC), and forms a spot in the lens base of a solid immersion lens 16. Contiguity arrangement of the base of a solid immersion lens 16 is carried out at surface 1a of a magneto-optic disk (optical record medium) 1, and surface 1a of a magneto-optic disk 1 is approaching to the approaching space field at the base of a lens of a solid immersion lens 16, and forms a condensing spot in recording surface 1a using the transmitted light and effusion light (EBANESSENTO light) of a solid immersion lens 16.
[0015] It is in the condition of carrying out high-speed rotation of the magneto-optic disk 1 in the horizontal plane the core [revolving-shaft 1b] on the occasion of record playback of the information by this equipment, and the condensing spot formed in surface 1a of a magneto-optic disk 1 performs record playback of the optical information on high density, making radial carry out scan migration of the solid immersion lens 16 according to the movable optical system 12, and adding a focus servo according to an objective lens 15 and a control system 17.
[0016] The refractive index of the silicon carbide which is the ingredient of a solid immersion lens 16 here is 2.63 in a laser beam with a wavelength of about 650nm. For this reason, with the combination of the semiconductor laser 10 and the solid immersion lens 16 made from silicon carbide which inject a laser beam with a wavelength of 650nm as mentioned above, compared with the case where the glass ingredient which is about 1.5 refractive index constitutes a solid immersion lens, the diameter of a condensing spot can be made into 57% of magnitude, and recording density can be made into about 3 times.
[0017] In addition, in the above-mentioned operation gestalt, although the laser beam with a wavelength of 650nm and the solid immersion lens made from silicon carbide were used, combination other than this may also be possible, for example, combination as shown in degree table 1 is sufficient.
[0018]
[Table 1]
An ingredient A refractive index (n) Wavelength (lambda) Diamond 2.41 650nm strontium titanate 2.4 650nm rutile 2.6 650nm gallium phosphide 3.3 650nm zinc sulfide 2.37 650nm arsenic sulfide 2.5 650nm lithium niobate 2.28 650nm zirconium dioxide 2.2 650nm silicon nitride 2.01 650nm [0019] Next, the 2nd operation gestalt of the optical record regenerative apparatus concerning this invention is explained with reference to drawing 2 and drawing 3 . This equipment has the information record reproducing head 20 approached and located on top-face recording surface 1a of the magneto-optic disk 1 by which a rotation drive is carried out a core [revolving-shaft 1b] with a spindle motor 2, and head arm equipment 30 holding this information record reproducing head 20, and is constituted.
[0020] The information record reproducing head 20 is equipped with the slider 21, and a slider 21 is located on top-face recording surface 1a of the rotating magneto-optic disk 1, and will be in the condition that only regularity minute distance surfaced from top-face recording surface 1a according to the air bearing effectiveness (that is, a flying head is constituted). Head arm equipment 30 consists of the arm section 33 horizontally prolonged from the upper limit of the revolving shaft 32 by which is connected with a voice coil motor 31 and a rotation drive is carried out, and this revolving shaft 32, and the suspension section 34 which supports it on the pars intermedia inferior surface of tongue of the arm

section 33 as permits migration of the upper and lower sides of the information record reproducing head 20. If the rotation drive of the revolving shaft 32 is carried out by the voice coil motor 31, rocking migration of the arm section 33 will be carried out horizontally, the information record reproducing head 20 is mostly moved in the direction of a right angle (radial) to the hand of cut of a magneto-optic disk 1, and the information record reproducing head 20 is scanned on top-face recording surface 1a of a magneto-optic disk 1. That is, tracking control is performed.

[0021] In the information record reproducing head 20, opening 21a of the shape of a circular taper which spreads up to a slider 21 is formed, the solid immersion lens 22 made from strontium titanate (SrTiO3) is arranged in opening 21a, and the objective lens 23 is arranged in the upper part. The arm section 33 of head arm equipment 30 is prolonged to the objective lens 23 and the location which counters up and down, and while that point has and carries out the reflector 35 which inclined 45 degrees, the high reflective film is prepared in this reflector 35 here. In addition, opening 21a may be made full of the ingredient which has transparence or light transmission nature.

[0022] The arm section 33 is formed from hollow or a transparent material, and the laser beam for record can penetrate the interior, as the chain line shows. The laser beam for record with a wavelength of 650nm is irradiated like the chain line through the arm section 33 from the record light irradiation device (laser light source) which is not illustrated, after being reflected in the reflector 35 with the high reflective film, it converges with an objective lens 23, and incidence of this laser beam is carried out to a solid immersion lens 22, and it forms a condensing spot in top-face recording surface 1a of a magneto-optic disk 1.

[0023] Actuation of the information record regenerative apparatus of the above configuration is explained. A magneto-optic disk 1 is first rotated at the rate of predetermined with a spindle motor 2, and the information record reproducing head 20 which was supported by the suspension section 34 of head arm equipment 30, and has been arranged on top-face recording surface 1a of a disk 1 is made into the condition that only minute distance surfaced from top-face recording surface 1a according to the air bearing effectiveness. In this condition, it is reflected in a reflector 35, and it converges with an objective lens 23, the laser light for record irradiated from the record light irradiation device is irradiated [it irradiates in accordance with the optical path shown with the chain line, and] by the solid immersion lens 22, and a condensing spot is formed in top-face recording surface 1a of a magneto-optic disk 1.

[0024] The magneto-optic disk 1 is driven by constant-speed rotation, the flying height of a slider 21 is always fixed, and this flying height is set up here so that a condensing spot may connect a focus to a top-face recording surface. For this reason, it is not necessary to establish a focusing device. moreover, the flying height -- **** -- it is minute, recording surface 1a of a magneto-optic disk 1 approaches to the approaching space field at the base of a lens of a solid immersion lens 22, and a condensing spot is formed of the transmitted light and effusion light of a solid immersion lens 22.

[0025] Thus, when recording information by the condensing spot light formed, the condensing spot section heats by the laser light irradiated here first more than Curie temperature, the magnetism of this part changes using the equipment which impresses an external magnetic field (magnetization reverses), information record performs, but since it is the thing of already the common knowledge about this, the equipment which impresses an external magnetic field does not illustrate, but also omits that actuation explanation. Moreover, the equipment which detects a magnetooptic Kerr effect is used about informational playback (reading), and illustration and its explanation are omitted also about this.

[0026] Although such information record is performed by moving the information record reproducing head 20 to radial [of a magneto-optic disk 1] corresponding to rotation of a magneto-optic disk 1 (scanning), the arm section 33 is rotated centering on a revolving shaft 32 with the voice coil motor 31 of head arm equipment 30, a scan, i.e., the tracking, of this information record reproducing head 20, and it is performed. In addition, it is good also by the linear mold actuator in this rotation.

[0027] In the case of this 2nd operation gestalt, a solid immersion lens 22 is made from strontium titanate, the laser beam for record with a wavelength of 650nm is irradiated from a record light irradiation device, a condensing spot is formed, and it is the refractive index n= 2.4 of the solid immersion lens 22 at this time. For this reason, a condensing spot smaller than the case where the solid

immersion lens made from a glass ingredient is used is formed, and high density record playback is possible.

[0028] Next, the 3rd operation gestalt of the optical record regenerative apparatus concerning this invention is explained with reference to drawing 4 . This equipment has the information record reproducing head 40 approached and located on top-face recording surface 1a of the magneto-optic disk 1 by which a rotation drive is carried out a core [revolving-shaft 1b] with a spindle motor 2, and head arm equipment 50 holding this information record reproducing head 40, and is constituted.

[0029] The information record reproducing head 40 is equipped with the slider 41, and a slider 41 is located on top-face recording surface 1a of the rotating magneto-optic disk 1, and will be in the condition that only regularity minute distance surfaced from top-face recording surface 1a according to the air bearing effectiveness. Head arm equipment 50 consists of the arm section 53 horizontally prolonged from the upper limit of the revolving shaft 52 by which is connected with a voice coil motor 51 and a rotation drive is carried out, and this revolving shaft 52, and the suspension section 54 which supports it in the point of the arm section 53 as permits migration of the upper and lower sides of the information record reproducing head 40. Rocking migration of the arm section 53 is horizontally carried out by the voice coil motor 51, the information record reproducing head 40 is mostly moved in the direction of a right angle (radial) to the hand of cut of a magneto-optic disk 1, and tracking control on top-face recording surface 1a of the magneto-optic disk 1 of the information record reproducing head 40 is performed.

[0030] In the information record reproducing head 40, opening 41a of the shape of a circular taper which spreads up to a slider 41 is formed, the solid immersion lens 42 made from silicon carbide (SiC) is arranged in opening 41a, and the objective lens 43 is arranged in the upper part. Furthermore, the micro prism 45 is located and arranged above the objective lens 43 through the spacer 44. In addition, the micro prism 45 has the reflector 46 in which the high reflective film was prepared. Also in this case, opening 41a may be made full of the ingredient which has transparence or light transmission nature.

[0031] With this equipment, the laser beam for record with a wavelength of 650nm is irradiated like the chain line toward the reflector 46 of the micro prism 45 from the record light irradiation device (laser light source) which is not illustrated, after being reflected in a reflector 46, it converges with an objective lens 43, and incidence of this laser beam is carried out to a solid immersion lens 42, and it forms a condensing spot in top-face recording surface 1a of a magneto-optic disk 1.

[0032] Since actuation of the information record regenerative apparatus of the above configuration is almost the same as that of the case of the 2nd operation gestalt shown in drawing 2 and drawing 3 , the explanation is omitted. In the case of this 3rd operation gestalt, a solid immersion lens 42 is made from silicon carbide (SiC), the laser beam for record with a wavelength of 650nm is irradiated from a record light irradiation device, a condensing spot is formed, and it is the refractive index n= 2.63 of the solid immersion lens 42 at this time. For this reason, a condensing spot smaller than the case where the solid immersion lens made from a glass ingredient is used is formed, and high density record playback is possible.

[0033] Next, the 4th operation gestalt of the optical record regenerative apparatus concerning this invention is explained with reference to drawing 5 . This equipment has the information record reproducing head 60 with the jogging micro mirror 64, and head arm equipment 70 holding this information record reproducing head 60, and is constituted.

[0034] The information record reproducing head 60 consists of the solid immersion lenses 62, the objective lenses 63, and the jogging micro mirrors 64 which were arranged like illustration on the slider 61 which surfaces on top-face recording surface 1a of the magneto-optic disk 1 which rotates by air bearing, and this slider 61. In addition, the jogging micro mirror 64 has the actuator 66 which can tune the inclination of the reflective mirror side 65 finely. Head arm equipment 70 consists of a revolving shaft 72 by which a rotation drive is carried out with a voice coil motor 71, the arm section 73 which leads to this revolving shaft 72, and the suspension section 74 which supports the information record reproducing head 60 in the point of the arm section 73.

[0035] Rocking migration of the arm section 73 is horizontally carried out by the voice coil motor 71.

Although the information record reproducing head 60 is mostly moved in the direction of a right angle (radial) to the hand of cut of a magneto-optic disk 1 and tracking control on top-face recording surface 1a of the magneto-optic disk 1 of the information record reproducing head 60 is performed At this time, the inclination of the reflective mirror side 65 can be finely tuned with an actuator 66 in the jogging micro mirror 64, minute tracking control can be performed, and tracking control in high degree of accuracy can be extremely performed now.

[0036] With this equipment, after the laser beam for record with a wavelength of 650nm is irradiated like the chain line toward the reflective mirror side 65 of the jogging micro mirror 64 and is reflected in the reflective mirror side 65 from the record light irradiation device (laser light source) which is not illustrated, it converges with an objective lens 63, incidence is carried out to a solid immersion lens 62, and a condensing spot is formed in top-face recording surface 1a of a magneto-optic disk 1. With this equipment, a solid immersion lens 62 is made from silicon carbide (SiC), the laser beam for record with a wavelength of 650nm is irradiated from a record light irradiation device, a condensing spot is formed, and it is the refractive index n= 2.63 of the solid immersion lens 62 at this time. For this reason, a condensing small spot is formed and high density record playback is possible.

[0037] Next, the 5th operation gestalt of the optical record regenerative apparatus concerning this invention is explained with reference to drawing 6 . In this equipment, the information record reproducing head 80 consists of the solid immersion lenses 82, the objective lenses 83, and the micro mirrors 84 which were arranged like illustration on the slider 81 which surfaces on top-face recording surface 1a of the magneto-optic disk 1 which rotates by air bearing, and this slider 81. In addition, as a solid immersion lens 82 is surrounded on the base of a slider 81, the micro coil 86 (refer to drawing 7) equipped with the coiled form conductive wiring 87 is embedded on it. By energizing to this conductive wiring 87, it is possible an over-write [perform the field modulation of the part which the micro coil 86 in recording surface 1a of a magneto-optic disk 1 counters, and / record].

[0038] Head arm equipment 90 consists of a revolving shaft 92 by which a rotation drive is carried out with a voice coil motor 91, the arm section 93 which leads to this revolving shaft 92, and the suspension section 94 which supports the information record reproducing head 80 through the jogging actuator 100 in the point of the arm section 93. The configuration of the jogging actuator 100 is shown in drawing 8 , and the laminating mold piezoelectric device 103 is arranged between the fixed block 101 connected with the arm section 93, and the movable block 102 connected with the suspension section 94, and it is constituted. The minute migration of the movable block 102 can be made to carry out in the direction of an arrow head to a fixed block 101 by performing energization control to a piezoelectric device 103. In addition, a jogging actuator may be replaced with the thing of a piezo-electric mold, and you may constitute from a thing of the type using electromagnetic force or electrostatic force.

[0039] Rocking migration of the arm section 93 is horizontally carried out by the voice coil motor 91, the information record reproducing head 80 is mostly moved in the direction of a right angle (radial) to the hand of cut of a magneto-optic disk 1, and tracking control on top-face recording surface 1a of the magneto-optic disk 1 of the information record reproducing head 80 is performed. At this time, the jogging actuator 100 can perform minute tracking control of the information record reproducing head 80, and tracking control in high degree of accuracy can be performed extremely.

[0040] With this equipment, after the laser beam for record with a wavelength of 650nm is irradiated like the chain line toward the reflective mirror side 85 of the micro mirror 84 and is reflected in the reflective mirror side 85 from the record light irradiation device (laser light source) which is not illustrated, it converges with an objective lens 83, incidence is carried out to a solid immersion lens 82, and a condensing spot is formed in top-face recording surface 1a of a magneto-optic disk 1. With this equipment, a solid immersion lens 82 is made from silicon carbide (SiC), the laser beam for record with a wavelength of 650nm is irradiated from a record light irradiation device, a condensing spot is formed, and it is the refractive index n= 2.63 of the solid immersion lens 82 at this time. For this reason, a condensing small spot is formed and high density record playback is possible.

[0041] Next, the 6th operation gestalt of the optical record regenerative apparatus concerning this invention is explained with reference to drawing 9 . In this equipment, the information record

reproducing head 110 consists of the solid immersion lenses 112, the objective lenses 113, and the micro mirrors 114 which were arranged like illustration on the slider 111 which surfaces on top-face recording surface 1a of the magneto-optic disk 1 which rotates by air bearing, and this slider 111. In addition, the micro coil 86 as shown in drawing 7 like the 5th operation gestalt is embedded on the base of a slider 111. It is possible an over-write [this performs the field modulation of the part which the micro coil 86 in recording surface 1a of a magneto-optic disk 1 counters, and / record].

[0042] The giant magneto-resistance component (GMR component) 130 used for playback of the information recorded on the magneto-optic disk 1 is attached at the tip of a slider 111 as the reproducing head. This giant magneto-resistance component 20 is explained with reference to drawing 10 - drawing 12 .

[0043] The enlarged display only of the magneto-resistive effect component 130 is taken out and carried out to drawing 10 , and it covers with the magnetic shielding 131,132 of the upper and lower sides of the GMR sensor 137 of 4 layer structure, and two electrodes 138,139 prepared on this, and is constituted so that drawing 11 which shows the cross section of this component 130, and drawing 12 may show well. The GMR sensor 137 is formed in four layers in piles like illustration of the antiferromagnetism film 133, the 1st magnetic film 134, a nonmagnetic membrane 135, and the 2nd ferromagnetic 136, and has the so-called spin bulb structure. In addition, Cu was used for the nonmagnetic membrane 135 at the 1st and 2nd magnetic films 134,136 at the antiferromagnetism film 133 using NiFe using FeMn.

[0044] Head arm equipment 120 consists of a revolving shaft 122 by which a rotation drive is carried out with a voice coil motor 121, the arm section 123 which leads to this revolving shaft 122, and the suspension section 124 which supports the information record reproducing head 110 in the point of the arm section 123. Rocking migration of the arm section 123 is horizontally carried out by the voice coil motor 121, the information record reproducing head 110 is mostly moved in the direction of a right angle (radial) to the hand of cut of a magneto-optic disk 1, and tracking control on top-face recording surface 1a of the magneto-optic disk 1 of the information record reproducing head 110 is performed.

[0045] With this equipment, after the laser beam for record with a wavelength of 650nm is irradiated like the chain line toward the reflective mirror side 115 of the micro mirror 114 and is reflected in the reflective mirror side 115 from the record light irradiation device (laser light source) which is not illustrated, it converges with an objective lens 113, incidence is carried out to a solid immersion lens 112, and a condensing spot is formed in top-face recording surface 1a of a magneto-optic disk 1. With this equipment, a solid immersion lens 112 is made from silicon carbide (SiC), the laser beam for record with a wavelength of 650nm is irradiated from a record light irradiation device, a condensing spot is formed, and it is the refractive index n= 2.63 of the solid immersion lens 82 at this time. For this reason, a condensing small spot is formed and high density record playback is possible.

[0046] Thus, when recording information by the condensing spot light formed, first, the condensing spot section is heated by the laser light irradiated here more than Curie temperature, the magnetism of this part is changed using the equipment which impresses the external magnetic field which is not illustrated (magnetization is reversed), and information record is performed. Playback of the information which did in this way on the other hand, and was recorded on the magneto-optic disk 2 is performed by the giant magneto-resistance component 130. This playback is performed where a sense current as carried out the seal of approval of the electrical potential difference between two electrodes 138,139 and shown in drawing by the arrow head C is passed in the GMR sensor 137, and it is performed using the magneto-resistive effect that magnetization of the GMR sensor 137 rotates by the field from a magneto-optic disk 1, and that electric resistance changes.

[0047] Electric resistance change of the GMR sensor 137 specifically takes place as follows. Since the 1st magnetic film 134 is in contact with the antiferromagnetism film 133, magnetization of the 1st magnetic film 134 is being fixed. On the other hand, magnetization of the 2nd magnetic film 136 rotates by the external magnetic field from a medium (magneto-optic disk). For this reason, if an external magnetic field is received, the sense of magnetization of the 1st and 2nd magnetic films 134,136 will change from parallel to anti-parallel. Here, when the magnetization direction of these two magnetic films 134,136 is the same (it is parallel), electric resistance becomes small small [magnetic dispersion

of the electron flowing in]. On the other hand, when the magnetization directions of a magnetic film 134,136 differ (they are anti-parallel), magnetic dispersion of the electron flowing in becomes large, and electric resistance also becomes large. Thus, if the giant magneto-resistance component 130 is used, a signal-to-noise ratio will be raised and it will become reproducible [information].

[0048]

[Effect of the Invention] According to this invention, as explained above, the ingredient of a solid immersion lens and the laser beam condensed by this solid immersion lens are chosen suitably, since a solid immersion lens and a laser beam are used under the combination of the conditions from which a refractive index becomes 2.0 or more, a solid immersion lens is used with a big refractive index, a condensing spot is made small, and record playback of the information on high density is attained.

[0049] In addition, it is desirable for it to be put on the recording surface of the record medium which carries out flat-surface movement, and to constitute an optical record regenerative apparatus using the slider which surfaces from this recording surface by air bearing, and is located, and to constitute so that a solid immersion lens may be arranged in a slider and scan migration of the slider may be carried out with a scan drive. If it does in this way, in order that a slider may always maintain a fixed distance by air bearing and may surface from a recording surface, the focal device of a lens becomes unnecessary. Moreover, the optical mirror for leading the laser beam bundle from a laser light source to a slider, an optical prism, an objective lens, etc. can be prepared, and an equipment configuration can be simplified.

[0050] Moreover, it is desirable to form the jogging actuator which forms the jogging actuator which makes the minute migration of the slider carry out in the scan migration direction and this direction in a scan drive, or tunes the inclination of the reflector of an optical prism or an optical mirror finely. Thereby, the degree of freedom of optical system becomes high, and highly precise tracking control becomes possible with a jogging actuator.

[0051] The component which has the giant magneto-resistance or the magneto-resistive effect for playback to a slider may be prepared, and the equipment which is a small compact and can perform highly precise playback by this can be obtained. Moreover, may prepare coiled form conductive wiring in the location which counters the record medium in a slider, this conductive wiring is made to perform the field modulation of a record medium, and over-writing of record is attained.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention relates to the equipment which performs information record and playback to record media, such as an optical disk, using a laser beam, especially the optical record regenerative apparatus which approaches a record medium and comes to arrange a solid immersion lens.

[0002]
[Description of the Prior Art] In recent years, the play back system which makes effectual numerical aperture of optical system one or more using a solid immersion lens (called a solid emersion lens or SIL) in the equipment which carries out record playback of the information optically or a system especially a magneto-optic-recording regenerative apparatus, or a system for the purpose of raising recording density is proposed.
[0003] An example of such an optical record regenerative apparatus is shown in drawing 13 , and it becomes the parallel flux of light within the fixed optical system 902, and the laser beam (wavelength of 650nm) injected from semiconductor laser 901 changes a direction by the mirror 904,905 within the movable optical system 903, is led to an objective lens 906, turns into light which condenses toward the solid immersion lens 907 made from semi-sphere-like glass (refractive index 1.5), and forms a spot in the lens base of a solid immersion lens 907. Contiguity arrangement of the base of a solid immersion lens 907 is carried out on the front face of the optical record medium (for example, magneto-optic disk) 910, and the front face of the optical record medium 910 is approaching to the approaching space field at the base of a lens of a solid immersion lens 907, and forms a condensing spot in a recording surface using the transmitted light and effusion light (EBANESSENTO light) of a solid immersion lens 907.
[0004] It is in the condition of carrying out high-speed rotation of the optical record medium 910 on the occasion of record playback of the information by this equipment, and the condensing spot formed in the front face of the optical record medium 910 performs record playback of the optical information on high density, making radial carry out scan migration of the solid immersion lens 907 according to the movable optical system 903, and adding a focus servo according to an objective lens 906 and a control system 908. Thus, the diameter of a condensing spot formed is decided by numerical-aperture N=n-sintheta (however, the refractive index of the n:solid immersion lens 907, theta: include angle which carries out incidence to a solid immersion lens) of a solid immersion lens 907, and wavelength lambda, and is lambda/(n-sintheta) mostly.
[0005]
[Problem(s) to be Solved by the Invention] In such an optical record regenerative apparatus, although the demand which makes the diameter of a condensing spot as small as possible, and raises recording density is strong, it is so desirable that wavelength lambda is so short that the refractive index n of a solid immersion lens is large in order to make the diameter of a condensing spot small so that the above-mentioned relation may show. Here, there is a limitation in short wavelength-ization of a laser beam, and when using semiconductor laser especially as a laser light source, although it is a red field

(wavelength of 600-700nm), by current, it is thought that a blue field (wavelength of 350-550nm) is also a minimum in the future. However, it was very difficult to enlarge a refractive index to the light of such short wavelength in the case of a glass ingredient.
[0006] This invention is what took the example by such situation, and it aims at forming a condensing spot smaller than before using a solid immersion lens, and offering the optical record regenerative apparatus in which optical record playback of high density is possible, and offering the solid immersion lens suitable for such equipment.
[0007]
[Means for Solving the Problem] For such purpose achievement, the solid immersion lens concerning this invention is made from the ingredient with which the refractive index to the light of some [with a wavelength of 350nm - 700nm / at least] wavelength range becomes 2.0 or more, and it is used in order to condense the light of some [this / at least] wavelength range and to make the condensing spot for optical record playback form. In addition, as an ingredient suitable for forming such a solid immersion lens, there are a diamond, strontium titanate, silicon carbide, a rutile, gallium phosphide, zinc sulfide, an arsenic sulfide, lithium niobate, a zirconium dioxide, silicon nitride, etc.
[0008] Moreover, the laser light source which the optical record regenerative apparatus concerning this invention makes generate the laser beam of some [with a wavelength of 350nm - 700nm / at least] wavelength range, The solid immersion lens in which are arranged in, and it is condensed and the condensing spot for record playback is made to approach on the surface of a record medium, and to form in response to the laser beam bundle which carries out incidence on the surface of a record medium (for example, magneto-optic disk) from a laser light source, The scan drive which makes the scan migration of the solid immersion lens carry out in the flat-surface movement direction and the different direction in the medium drive to which flat-surface movement (rotation) of the record medium is carried out, and the condition of having made the solid immersion lens approaching the front face of the record medium which is carrying out flat-surface movement (For example, head arm equipment) It has, and it is constituted and the solid immersion lens is made from the ingredient with which the refractive index to the laser beam from a laser light source becomes 2.0 or more.
[0009] Thus, in this invention, the ingredient of a solid immersion lens and the laser beam condensed by this solid immersion lens are chosen suitably, and a solid immersion lens and a laser beam are used under the combination of the conditions from which a refractive index becomes 2.0 or more. For this reason, a solid immersion lens is used with a big refractive index, a condensing spot is made small, and record playback of the information on high density is attained.
[0010] In addition, it is desirable to constitute so that it may be put on the recording surface of the record medium which is carrying out flat-surface movement with the medium drive, an optical record regenerative apparatus can be constituted using the slider which surfaces from this recording surface by air bearing, and is located, a solid immersion lens may be arranged by the slider in this case and scan migration of the slider may be carried out by the scan drive. If it does in this way, in order that a slider may always maintain a fixed distance by air bearing and may surface from a recording surface, the focal device of a lens becomes unnecessary. Moreover, the objective lens which a slider is made to condense the laser beam bundle from a laser light source, and is made to irradiate a solid immersion lens can be prepared, and a configuration can be simplified.
[0011] Moreover, it is desirable to form the jogging actuator which makes the minute migration of the slider carry out in the scan migration direction and this direction in a scan drive. Thereby, in a scan drive, control performs difficult fine tracking control and the higher-density and highly precise record playback of it is attained.
[0012] The optical prism or optical mirror for reflecting the laser beam from a laser light source in a slider, and leading to an objective lens can be prepared. In this case, it is desirable to form the jogging actuator which tunes the inclination of the reflector of an optical prism or an optical mirror finely. Thereby, the degree of freedom of optical system becomes high, and it becomes possible in highly precise tracking control with a jogging actuator.
[0013] The component which has the giant magneto-resistance or the magneto-resistive effect for

playback to a slider may be prepared, and the equipment which is a small compact and can perform highly precise playback by this can be obtained. Moreover, may prepare coiled form conductive wiring in the location which counters the record medium in a slider, this conductive wiring is made to perform the field modulation of a record medium, and over-writing of record is attained.
[0014]
[Embodiment of the Invention] Hereafter, the desirable operation gestalt of this invention is explained with reference to a drawing. The 1st operation gestalt of the optical record regenerative apparatus concerning this invention is shown in drawing 1 , a laser beam with a wavelength of about 650nm is irradiated toward the fixed optical system 11 from semiconductor laser 10, in the fixed optical system 11, it becomes the parallel flux of light, and the 1st mirror 13 within the movable optical system 12 irradiates. Thus, the irradiated laser beam can change a direction by the 1st and 2nd mirrors 13 and 14 in the movable optical system 12, is led to an objective lens 15, turns into light which condenses toward the solid immersion lens 16 made from semi-sphere-like silicon carbide (SiC), and forms a spot in the lens base of a solid immersion lens 16. Contiguity arrangement of the base of a solid immersion lens 16 is carried out at surface 1a of a magneto-optic disk (optical record medium) 1, and surface 1a of a magneto-optic disk 1 is approaching to the approaching space field at the base of a lens of a solid immersion lens 16, and forms a condensing spot in recording surface 1a using the transmitted light and effusion light (EBANESSENTO light) of a solid immersion lens 16.
[0015] It is in the condition of carrying out high-speed rotation of the magneto-optic disk 1 in the horizontal plane the core [revolving-shaft 1b] on the occasion of record playback of the information by this equipment, and the condensing spot formed in surface 1a of a magneto-optic disk 1 performs record playback of the optical information on high density, making radial carry out scan migration of the solid immersion lens 16 according to the movable optical system 12, and adding a focus servo according to an objective lens 15 and a control system 17.
[0016] The refractive index of the silicon carbide which is the ingredient of a solid immersion lens 16 here is 2.63 in a laser beam with a wavelength of about 650nm. For this reason, with the combination of the semiconductor laser 10 and the solid immersion lens 16 made from silicon carbide which inject a laser beam with a wavelength of 650nm as mentioned above, compared with the case where the glass ingredient which is about 1.5 refractive index constitutes a solid immersion lens, the diameter of a condensing spot can be made into 57% of magnitude, and recording density can be made into about 3 times.
[0017] In addition, in the above-mentioned operation gestalt, although the laser beam with a wavelength of 650nm and the solid immersion lens made from silicon carbide were used, combination other than this may also be possible, for example, combination as shown in degree table 1 is sufficient.
[0018]
[Table 1]
An ingredient A refractive index (n) Wavelength (lambda) Diamond 2.41 650nm strontium titanate 2.4 650nm rutile 2.6 650nm gallium phosphide 3.3 650nm zinc sulfide 2.37 650nm arsenic sulfide 2.5 650nm lithium niobate 2.28 650nm zirconium dioxide 2.2 650nm silicon nitride 2.01 650nm [0019] Next, the 2nd operation gestalt of the optical record regenerative apparatus concerning this invention is explained with reference to drawing 2 and drawing 3 . This equipment has the information record reproducing head 20 approached and located on top-face recording surface 1a of the magneto-optic disk 1 by which a rotation drive is carried out a core [revolving-shaft 1b] with a spindle motor 2, and head arm equipment 30 holding this information record reproducing head 20, and is constituted.
[0020] The information record reproducing head 20 is equipped with the slider 21, and a slider 21 is located on top-face recording surface 1a of the rotating magneto-optic disk 1, and will be in the condition that only regularity minute distance surfaced from top-face recording surface 1a according to the air bearing effectiveness (that is, a flying head is constituted). Head arm equipment 30 consists of the arm section 33 horizontally prolonged from the upper limit of the revolving shaft 32 by which is connected with a voice coil motor 31 and a rotation drive is carried out, and this revolving shaft 32, and the suspension section 34 which supports it on the pars intermedia inferior surface of tongue of the arm

section 33 as permits migration of the upper and lower sides of the information record reproducing head 20. If the rotation drive of the revolving shaft 32 is carried out by the voice coil motor 31, rocking migration of the arm section 33 will be carried out horizontally, the information record reproducing head 20 is mostly moved in the direction of a right angle (radial) to the hand of cut of a magneto-optic disk 1, and the information record reproducing head 20 is scanned on top-face recording surface 1a of a magneto-optic disk 1. That is, tracking control is performed.

[0021] In the information record reproducing head 20, opening 21a of the shape of a circular taper which spreads up to a slider 21 is formed, the solid immersion lens 22 made from strontium titanate (SrTiO3) is arranged in opening 21a, and the objective lens 23 is arranged in the upper part. The arm section 33 of head arm equipment 30 is prolonged to the objective lens 23 and the location which counters up and down, and while that point has and carries out the reflector 35 which inclined 45 degrees, the high reflective film is prepared in this reflector 35 here. In addition, opening 21a may be made full of the ingredient which has transparence or light transmission nature.

[0022] The arm section 33 is formed from hollow or a transparent material, and the laser beam for record can penetrate the interior, as the chain line shows. The laser beam for record with a wavelength of 650nm is irradiated like the chain line through the arm section 33 from the record light irradiation device (laser light source) which is not illustrated, after being reflected in the reflector 35 with the high reflective film, it converges with an objective lens 23, and incidence of this laser beam is carried out to a solid immersion lens 22, and it forms a condensing spot in top-face recording surface 1a of a magneto-optic disk 1.

[0023] Actuation of the information record regenerative apparatus of the above configuration is explained. A magneto-optic disk 1 is first rotated at the rate of predetermined with a spindle motor 2, and the information record reproducing head 20 which was supported by the suspension section 34 of head arm equipment 30, and has been arranged on top-face recording surface 1a of a disk 1 is made into the condition that only minute distance surfaced from top-face recording surface 1a according to the air bearing effectiveness. In this condition, it is reflected in a reflector 35, and it converges with an objective lens 23, the laser light for record irradiated from the record light irradiation device is irradiated [it irradiates in accordance with the optical path shown with the chain line, and] by the solid immersion lens 22, and a condensing spot is formed in top-face recording surface 1a of a magneto-optic disk 1.

[0024] The magneto-optic disk 1 is driven by constant-speed rotation, the flying height of a slider 21 is always fixed, and this flying height is set up here so that a condensing spot may connect a focus to a top-face recording surface. For this reason, it is not necessary to establish a focusing device. moreover, the flying height -- **** -- it is minute, recording surface 1a of a magneto-optic disk 1 approaches to the approaching space field at the base of a lens of a solid immersion lens 22, and a condensing spot is formed of the transmitted light and effusion light of a solid immersion lens 22.

[0025] Thus, when recording information by the condensing spot light formed, the condensing spot section heats by the laser light irradiated here first more than Curie temperature, the magnetism of this part changes using the equipment which impresses an external magnetic field (magnetization reverses), information record performs, but since it is the thing of already the common knowledge about this, the equipment which impresses an external magnetic field does not illustrate, but also omits that actuation explanation. Moreover, the equipment which detects a magnetooptic Kerr effect is used about informational playback (reading), and illustration and its explanation are omitted also about this.

[0026] Although such information record is performed by moving the information record reproducing head 20 to radial [of a magneto-optic disk 1] corresponding to rotation of a magneto-optic disk 1 (scanning), the arm section 33 is rotated centering on a revolving shaft 32 with the voice coil motor 31 of head arm equipment 30, a scan, i.e., the tracking, of this information record reproducing head 20, and it is performed. In addition, it is good also by the linear mold actuator in this rotation.

[0027] In the case of this 2nd operation gestalt, a solid immersion lens 22 is made from strontium titanate, the laser beam for record with a wavelength of 650nm is irradiated from a record light irradiation device, a condensing spot is formed, and it is the refractive index n= 2.4 of the solid immersion lens 22 at this time. For this reason, a condensing spot smaller than the case where the solid

immersion lens made from a glass ingredient is used is formed, and high density record playback is possible.

[0028] Next, the 3rd operation gestalt of the optical record regenerative apparatus concerning this invention is explained with reference to drawing 4 . This equipment has the information record reproducing head 40 approached and located on top-face recording surface 1a of the magneto-optic disk 1 by which a rotation drive is carried out a core [revolving-shaft 1b] with a spindle motor 2, and head arm equipment 50 holding this information record reproducing head 40, and is constituted.

[0029] The information record reproducing head 40 is equipped with the slider 41, and a slider 41 is located on top-face recording surface 1a of the rotating magneto-optic disk 1, and will be in the condition that only regularity minute distance surfaced from top-face recording surface 1a according to the air bearing effectiveness. Head arm equipment 50 consists of the arm section 53 horizontally prolonged from the upper limit of the revolving shaft 52 by which is connected with a voice coil motor 51 and a rotation drive is carried out, and this revolving shaft 52, and the suspension section 54 which supports it in the point of the arm section 53 as permits migration of the upper and lower sides of the information record reproducing head 40. Rocking migration of the arm section 53 is horizontally carried out by the voice coil motor 51, the information record reproducing head 40 is mostly moved in the direction of a right angle (radial) to the hand of cut of a magneto-optic disk 1, and tracking control on top-face recording surface 1a of the magneto-optic disk 1 of the information record reproducing head 40 is performed.

[0030] In the information record reproducing head 40, opening 41a of the shape of a circular taper which spreads up to a slider 41 is formed, the solid immersion lens 42 made from silicon carbide (SiC) is arranged in opening 41a, and the objective lens 43 is arranged in the upper part. Furthermore, the micro prism 45 is located and arranged above the objective lens 43 through the spacer 44. In addition, the micro prism 45 has the reflector 46 in which the high reflective film was prepared. Also in this case, opening 41a may be made full of the ingredient which has transparence or light transmission nature.

[0031] With this equipment, the laser beam for record with a wavelength of 650nm is irradiated like the chain line toward the reflector 46 of the micro prism 45 from the record light irradiation device (laser light source) which is not illustrated, after being reflected in a reflector 46, it converges with an objective lens 43, and incidence of this laser beam is carried out to a solid immersion lens 42, and it forms a condensing spot in top-face recording surface 1a of a magneto-optic disk 1.

[0032] Since actuation of the information record regenerative apparatus of the above configuration is almost the same as that of the case of the 2nd operation gestalt shown in drawing 2 and drawing 3 , the explanation is omitted. In the case of this 3rd operation gestalt, a solid immersion lens 42 is made from silicon carbide (SiC), the laser beam for record with a wavelength of 650nm is irradiated from a record light irradiation device, a condensing spot is formed, and it is the refractive index n= 2.63 of the solid immersion lens 42 at this time. For this reason, a condensing spot smaller than the case where the solid immersion lens made from a glass ingredient is used is formed, and high density record playback is possible.

[0033] Next, the 4th operation gestalt of the optical record regenerative apparatus concerning this invention is explained with reference to drawing 5 . This equipment has the information record reproducing head 60 with the jogging micro mirror 64, and head arm equipment 70 holding this information record reproducing head 60, and is constituted.

[0034] The information record reproducing head 60 consists of the solid immersion lenses 62, the objective lenses 63, and the jogging micro mirrors 64 which were arranged like illustration on the slider 61 which surfaces on top-face recording surface 1a of the magneto-optic disk 1 which rotates by air bearing, and this slider 61. In addition, the jogging micro mirror 64 has the actuator 66 which can tune the inclination of the reflective mirror side 65 finely. Head arm equipment 70 consists of a revolving shaft 72 by which a rotation drive is carried out with a voice coil motor 71, the arm section 73 which leads to this revolving shaft 72, and the suspension section 74 which supports the information record reproducing head 60 in the point of the arm section 73.

[0035] Rocking migration of the arm section 73 is horizontally carried out by the voice coil motor 71.

Although the information record reproducing head 60 is mostly moved in the direction of a right angle (radial) to the hand of cut of a magneto-optic disk 1 and tracking control on top-face recording surface 1a of the magneto-optic disk 1 of the information record reproducing head 60 is performed At this time, the inclination of the reflective mirror side 65 can be finely tuned with an actuator 66 in the jogging micro mirror 64, minute tracking control can be performed, and tracking control in high degree of accuracy can be extremely performed now.

[0036] With this equipment, after the laser beam for record with a wavelength of 650nm is irradiated like the chain line toward the reflective mirror side 65 of the jogging micro mirror 64 and is reflected in the reflective mirror side 65 from the record light irradiation device (laser light source) which is not illustrated, it converges with an objective lens 63, incidence is carried out to a solid immersion lens 62, and a condensing spot is formed in top-face recording surface 1a of a magneto-optic disk 1. With this equipment, a solid immersion lens 62 is made from silicon carbide (SiC), the laser beam for record with a wavelength of 650nm is irradiated from a record light irradiation device, a condensing spot is formed, and it is the refractive index n= 2.63 of the solid immersion lens 62 at this time. For this reason, a condensing small spot is formed and high density record playback is possible.

[0037] Next, the 5th operation gestalt of the optical record regenerative apparatus concerning this invention is explained with reference to drawing 6 . In this equipment, the information record reproducing head 80 consists of the solid immersion lenses 82, the objective lenses 83, and the micro mirrors 84 which were arranged like illustration on the slider 81 which surfaces on top-face recording surface 1a of the magneto-optic disk 1 which rotates by air bearing, and this slider 81. In addition, as a solid immersion lens 82 is surrounded on the base of a slider 81, the micro coil 86 (refer to drawing 7) equipped with the coiled form conductive wiring 87 is embedded on it. By energizing to this conductive wiring 87, it is possible an over-write [perform the field modulation of the part which the micro coil 86 in recording surface 1a of a magneto-optic disk 1 counters, and / record].

[0038] Head arm equipment 90 consists of a revolving shaft 92 by which a rotation drive is carried out with a voice coil motor 91, the arm section 93 which leads to this revolving shaft 92, and the suspension section 94 which supports the information record reproducing head 80 through the jogging actuator 100 in the point of the arm section 93. The configuration of the jogging actuator 100 is shown in drawing 8 , and the laminating mold piezoelectric device 103 is arranged between the fixed block 101 connected with the arm section 93, and the movable block 102 connected with the suspension section 94, and it is constituted. The minute migration of the movable block 102 can be made to carry out in the direction of an arrow head to a fixed block 101 by performing energization control to a piezoelectric device 103. In addition, a jogging actuator may be replaced with the thing of a piezo-electric mold, and you may constitute from a thing of the type using electromagnetic force or electrostatic force.

[0039] Rocking migration of the arm section 93 is horizontally carried out by the voice coil motor 91, the information record reproducing head 80 is mostly moved in the direction of a right angle (radial) to the hand of cut of a magneto-optic disk 1, and tracking control on top-face recording surface 1a of the magneto-optic disk 1 of the information record reproducing head 80 is performed. At this time, the jogging actuator 100 can perform minute tracking control of the information record reproducing head 80, and tracking control in high degree of accuracy can be performed extremely.

[0040] With this equipment, after the laser beam for record with a wavelength of 650nm is irradiated like the chain line toward the reflective mirror side 85 of the micro mirror 84 and is reflected in the reflective mirror side 85 from the record light irradiation device (laser light source) which is not illustrated, it converges with an objective lens 83, incidence is carried out to a solid immersion lens 82, and a condensing spot is formed in top-face recording surface 1a of a magneto-optic disk 1. With this equipment, a solid immersion lens 82 is made from silicon carbide (SiC), the laser beam for record with a wavelength of 650nm is irradiated from a record light irradiation device, a condensing spot is formed, and it is the refractive index n= 2.63 of the solid immersion lens 82 at this time. For this reason, a condensing small spot is formed and high density record playback is possible.

[0041] Next, the 6th operation gestalt of the optical record regenerative apparatus concerning this invention is explained with reference to drawing 9 . In this equipment, the information record

reproducing head 110 consists of the solid immersion lenses 112, the objective lenses 113, and the micro mirrors 114 which were arranged like illustration on the slider 111 which surfaces on top-face recording surface 1a of the magneto-optic disk 1 which rotates by air bearing, and this slider 111. In addition, the micro coil 86 as shown in drawing 7 like the 5th operation gestalt is embedded on the base of a slider 111. It is possible an over-write [this performs the field modulation of the part which the micro coil 86 in recording surface 1a of a magneto-optic disk 1 counters, and / record].

[0042] The giant magneto-resistance component (GMR component) 130 used for playback of the information recorded on the magneto-optic disk 1 is attached at the tip of a slider 111 as the reproducing head. This giant magneto-resistance component 20 is explained with reference to drawing 10 - drawing 12 .

[0043] The enlarged display only of the magneto-resistive effect component 130 is taken out and carried out to drawing 10 , and it covers with the magnetic shielding 131,132 of the upper and lower sides of the GMR sensor 137 of 4 layer structure, and two electrodes 138,139 prepared on this, and is constituted so that drawing 11 which shows the cross section of this component 130, and drawing 12 may show well. The GMR sensor 137 is formed in four layers in piles like illustration of the antiferromagnetism film 133, the 1st magnetic film 134, a nonmagnetic membrane 135, and the 2nd ferromagnetic 136, and has the so-called spin bulb structure. In addition, Cu was used for the nonmagnetic membrane 135 at the 1st and 2nd magnetic films 134,136 at the antiferromagnetism film 133 using NiFe using FeMn.

[0044] Head arm equipment 120 consists of a revolving shaft 122 by which a rotation drive is carried out with a voice coil motor 121, the arm section 123 which leads to this revolving shaft 122, and the suspension section 124 which supports the information record reproducing head 110 in the point of the arm section 123. Rocking migration of the arm section 123 is horizontally carried out by the voice coil motor 121, the information record reproducing head 110 is mostly moved in the direction of a right angle (radial) to the hand of cut of a magneto-optic disk 1, and tracking control on top-face recording surface 1a of the magneto-optic disk 1 of the information record reproducing head 110 is performed.

[0045] With this equipment, after the laser beam for record with a wavelength of 650nm is irradiated like the chain line toward the reflective mirror side 115 of the micro mirror 114 and is reflected in the reflective mirror side 115 from the record light irradiation device (laser light source) which is not illustrated, it converges with an objective lens 113, incidence is carried out to a solid immersion lens 112, and a condensing spot is formed in top-face recording surface 1a of a magneto-optic disk 1. With this equipment, a solid immersion lens 112 is made from silicon carbide (SiC), the laser beam for record with a wavelength of 650nm is irradiated from a record light irradiation device, a condensing spot is formed, and it is the refractive index n= 2.63 of the solid immersion lens 82 at this time. For this reason, a condensing small spot is formed and high density record playback is possible.

[0046] Thus, when recording information by the condensing spot light formed, first, the condensing spot section is heated by the laser light irradiated here more than Curie temperature, the magnetism of this part is changed using the equipment which impresses the external magnetic field which is not illustrated (magnetization is reversed), and information record is performed. Playback of the information which did in this way on the other hand, and was recorded on the magneto-optic disk 2 is performed by the giant magneto-resistance component 130. This playback is performed where a sense current as carried out the seal of approval of the electrical potential difference between two electrodes 138,139 and shown in drawing by the arrow head C is passed in the GMR sensor 137, and it is performed using the magneto-resistive effect that magnetization of the GMR sensor 137 rotates by the field from a magneto-optic disk 1, and that electric resistance changes.

[0047] Electric resistance change of the GMR sensor 137 specifically takes place as follows. Since the 1st magnetic film 134 is in contact with the antiferromagnetism film 133, magnetization of the 1st magnetic film 134 is being fixed. On the other hand, magnetization of the 2nd magnetic film 136 rotates by the external magnetic field from a medium (magneto-optic disk). For this reason, if an external magnetic field is received, the sense of magnetization of the 1st and 2nd magnetic films 134,136 will change from parallel to anti-parallel. Here, when the magnetization direction of these two magnetic films 134,136 is the same (it is parallel), electric resistance becomes small small [magnetic dispersion

of the electron flowing in]. On the other hand, when the magnetization directions of a magnetic film 134,136 differ (they are anti-parallel), magnetic dispersion of the electron flowing in becomes large, and electric resistance also becomes large. Thus, if the giant magneto-resistance component 130 is used, a signal-to-noise ratio will be raised and it will become reproducible [information].
[0048]
[Effect of the Invention] According to this invention, as explained above, the ingredient of a solid immersion lens and the laser beam condensed by this solid immersion lens are chosen suitably, since a solid immersion lens and a laser beam are used under the combination of the conditions from which a refractive index becomes 2.0 or more, a solid immersion lens is used with a big refractive index, a condensing spot is made small, and record playback of the information on high density is attained.
[0049] In addition, it is desirable for it to be put on the recording surface of the record medium which carries out flat-surface movement, and to constitute an optical record regenerative apparatus using the slider which surfaces from this recording surface by air bearing, and is located, and to constitute so that a solid immersion lens may be arranged in a slider and scan migration of the slider may be carried out with a scan drive. If it does in this way, in order that a slider may always maintain a fixed distance by air bearing and may surface from a recording surface, the focal device of a lens becomes unnecessary. Moreover, the optical mirror for leading the laser beam bundle from a laser light source to a slider, an optical prism, an objective lens, etc. can be prepared, and an equipment configuration can be simplified.
[0050] Moreover, it is desirable to form the jogging actuator which forms the jogging actuator which makes the minute migration of the slider carry out in the scan migration direction and this direction in a scan drive, or tunes the inclination of the reflector of an optical prism or an optical mirror finely. Thereby, the degree of freedom of optical system becomes high, and highly precise tracking control becomes possible with a jogging actuator.
[0051] The component which has the giant magneto-resistance or the magneto-resistive effect for playback to a slider may be prepared, and the equipment which is a small compact and can perform highly precise playback by this can be obtained. Moreover, may prepare coiled form conductive wiring in the location which counters the record medium in a slider, this conductive wiring is made to perform the field modulation of a record medium, and over-writing of record is attained.

[Translation done.]

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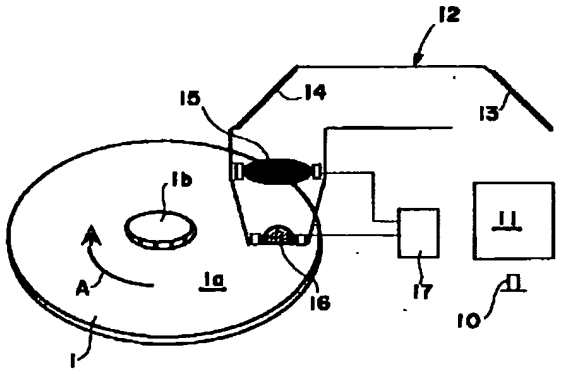
(57)【要約】

【課題】　高密度の光学記録再生が可能な光学記録再生装置およびこの装置に適した固体浸レンズを得る。

【解決手段】　波長３５０ｎｍ～７００ｎｍの少なくとも一部の波長範囲のレーザ光を発生させるレーザ光源１０と、光磁気ディスク１の表面記録面１ａに近接して配設されてレーザ光源からの光を集光する対物レンズ１５と、この対物レンズからのレーザ光束を受けて記録再生用の集光スポットを記録面に形成させる固体浸レンズ１６と、光磁気ディスク１を回転させるモータと、固体浸レンズを回転している光磁気ディスクの記録面に近接させた状態で固体浸レンズを半径方向に走査移動させる可動光学系１２とを有して構成される。ここで、固体浸レンズ１６は、レーザ光源１０からのレーザ光に対する屈折率が２．０以上となる材料から作られている。



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【特許請求の範囲】

【請求項1】　波長350nm～700nmの少なくとも一部の波長範囲の光に対する屈折率が2．0以上となる材料から作られ、

前記少なくとも一部の波長範囲の光を集光して光学記録再生用の集光スポットを形成させために用いられることを特徴とする光学記録再生用固体浸レンズ。

【請求項2】　前記材料が、ダイヤモンド、チタン酸ストロンチウム、シリコンカーバイド、ルチル、ガリウム燐、硫化亜鉛、硫化砒素、ニオブ酸リチウム、酸化ジルコニウム、窒化シリコンのいずれかであることを特徴とする請求項1に記載の光学記録再生用固体浸レンズ。

【請求項3】　波長350nm～700nmの少なくとも一部の波長範囲のレーザ光を発生させるレーザ光源と、

光学記録再生用の記録媒体の表面に近接して配設され、前記レーザ光源から集光されて入射するレーザ光束を受けて記録再生用の集光スポットを前記記録媒体の表面に形成させる固体浸レンズと、

前記記録媒体を平面運動させる媒体駆動機構と、

前記固体浸レンズを平面運動している前記記録媒体の表面に近接させた状態で、前記固体浸レンズを前記平面運動方向と異なる方向に走査移動させる走査駆動機構とを有して構成され、

前記固体浸レンズが、前記レーザ光源からの前記レーザ光に対する屈折率が2．0以上となる材料から作られていることを特徴とする光学記録再生装置。

【請求項4】　前記媒体駆動機構により平面運動している前記記録媒体の記録面に置かれて空気ベアリングによりこの記録面から浮上して位置するスライダーを有し、このスライダーに前記固体浸レンズが配設されており、前記走査駆動機構により前記スライダーが走査移動されることを特徴とする請求項3に記載の光学記録再生装置。

【請求項5】　前記スライダーに前記レーザ光源からのレーザ光束を集光させて前記固体浸レンズに照射させる対物レンズが設けられていることを特徴とする請求項4に記載の光学記録再生装置。

【請求項6】　前記走査駆動機構に、前記スライダーを前記走査移動方向と同方向に微小移動させる微動アクチュエータを有することを特徴とする請求項4もしくは5に記載の光学記録再生装置。

【請求項7】　前記スライダーに前記レーザ光源からのレーザ光を反射して前記対物レンズに導くための光学プリズムもしくは光学ミラーが設けられていることを特徴とする請求項4～6のいずれかに記載の光学記録再生装置。

【請求項8】　前記光学プリズムもしくは光学ミラーの反射面の傾きを微調整する微動アクチュエータを有することを特徴とする請求項7に記載の光学記録再生装置。

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【請求項9】　前記スライダーに、再生用の巨大磁気抵抗効果もしくは磁気抵抗効果を有する素子を設けたことを特徴とする請求項4～8のいずれかに記載の光学記録再生装置。

【請求項10】　前記スライダーにおける前記記録媒体に対向する位置にコイル状の導電性配線が設けられ、この導電性配線により前記記録媒体の磁界変調を行わせることが可能であることを特徴とする請求項4～9のいずれかに記載の光学記録再生装置。

【発明の詳細な説明】

【0001】

【発明の属する技術分野】本発明は、レーザ光を用いて光ディスクなどの記録媒体への情報記録・再生を行う装置、特に記録媒体に近接して固体浸レンズを配設してなる光学記録再生装置に関する。

【0002】

【従来の技術】近年、光学的に情報を記録再生する装置またはシステム、特に光磁気記録再生装置またはシステムにおいて、記録密度を向上させることを目的として、固体浸レンズ（ソリッドイマージョンレンズまたはＳＩＬとも称される）を用いて光学系の実効的な開口数を1以上にする記録再生方式が提案されている。

【0003】このような光学記録再生装置の一例を図13に示しており、半導体レーザ901から射出されたレーザ光（波長650nm）が固定光学系902内で平行光束となり、可動光学系903内のミラー904，905により方向を変えて対物レンズ906に導かれ、半球状のガラス（屈折率1．5）を材料とする固体浸レンズ907に向かって集光する光となり、固体浸レンズ907のレンズ底面にスポットを形成する。固体浸レンズ907の底面は光学記録媒体（例えば、光磁気ディスク）910の表面に近接配設され、光学記録媒体910の表面は固体浸レンズ907のレンズ底面の近接場領域まで近づいており、固体浸レンズ907の透過光と浸み出し光（エバネッセント光）を使って記録面に集光スポットを形成する。

【0004】この装置による情報の記録再生に際しては、光学記録媒体910を高速回転させた状態で、可動光学系903により固体浸レンズ907を半径方向に走査移動させ、対物レンズ906と制御系908によってフォーカスサーボを加えつつ、光学記録媒体910の表面に形成した集光スポットにより高密度の光学的な情報の記録再生を行う。このようにして形成される集光スポット径は、固体浸レンズ907の開口数$N=n\cdot\sin\theta$（但し、n：固体浸レンズ907の屈折率、θ：固体浸レンズに入射する角度）と波長λで決まり、ほぼ$\lambda/(n\cdot\sin\theta)$である。

【0005】

【発明が解決しようとする課題】このような光学記録再生装置においては、集光スポット径をできる限り小さく

して記録密度を高める要求が強いが、上記の関係から分かるように、集光スポット径を小さくするには、固体浸レンズの屈折率nが大きいほど、また、波長λが短いほど好ましい。ここで、レーザ光の短波長化には限界があり、特にレーザ光源として半導体レーザを用いる場合、現在では赤色領域（波長６００～７００ｎｍ）であるが将来的にも青色領域（波長３５０～５５０ｎｍ）が下限であると考えられる。しかしながら、このような短波長の光に対してガラス材料の場合には、屈折率を大きくするのは非常に困難であった。

【０００６】本発明はこのような事情に鑑みたもので、固体浸レンズを用いて従来より小さな集光スポットを形成して高密度の光学記録再生が可能な光学記録再生装置を提供すること、およびこのような装置に適した固体浸レンズを提供することを目的とする。

【０００７】

【課題を解決するための手段】このような目的達成のため、本発明に係る固体浸レンズは、波長３５０ｎｍ～７００ｎｍの少なくとも一部の波長範囲の光に対する屈折率が２．０以上となる材料から作られ、この少なくとも一部の波長範囲の光を集光して光学記録再生用の集光スポットを形成させるために用いられる。なお、このような固体浸レンズを形成するに適した材料としては、ダイヤモンド、チタン酸ストロンチウム、シリコンカーバイド、ルチル、ガリウム燐、硫化亜鉛、硫化砒素、ニオブ酸リチウム、酸化ジルコニウム、窒化シリコン等がある。

【０００８】また、本発明に係る光学記録再生装置は、波長３５０ｎｍ～７００ｎｍの少なくとも一部の波長範囲のレーザ光を発生させるレーザ光源と、記録媒体の表面に近接して配設されてレーザ光源から集光されて入射するレーザ光束を受けて記録再生用の集光スポットを記録媒体（例えば、光磁気ディスク）の表面に形成させる固体浸レンズと、記録媒体を平面運動（回転運動）させる媒体駆動機構と、固体浸レンズを平面運動している記録媒体の表面に近接させた状態で固体浸レンズを平面運動方向と異なる方向に走査移動させる走査駆動機構（例えば、ヘッドアーム装置）とを有して構成され、固体浸レンズは、レーザ光源からのレーザ光に対する屈折率が２．０以上となる材料から作られている。

【０００９】このように本発明においては、固体浸レンズの材料とこの固体浸レンズにより集光されるレーザ光とを適宜選択し、屈折率が２．０以上となる条件の組み合わせの下で固体浸レンズおよびレーザ光を使用する。このため、固体浸レンズを大きな屈折率で使用し、集光スポットを小さくして高密度での情報の記録再生が可能となる。

【００１０】なお、媒体駆動機構により平面運動している記録媒体の記録面に置かれて空気ベアリングによりこの記録面から浮上して位置するスライダーを用いて光学記録再生装置を構成することができ、この場合、スライダーに固体浸レンズが配設され、走査駆動機構によりスライダーが走査移動されるように構成するのが好ましい。このようにすれば、スライダーが空気ベアリングにより常に一定の距離を保って記録面から浮上するため、レンズのフォーカス機構が不要となる。また、スライダーにレーザ光源からのレーザ光束を集光させて固体浸レンズに照射させる対物レンズを設けることができ、構成を簡単にすることができる。

【００１１】また、走査駆動機構に、スライダーを走査移動方向と同方向に微小移動させる微動アクチュエータを設けるのが好ましい。これにより、走査駆動機構では制御が難しい、細かなトラッキング制御を行ってより高密度で高精度の記録再生が可能となる。

【００１２】スライダーにレーザ光源からのレーザ光を反射して対物レンズに導くための光学プリズムもしくは光学ミラーを設けることができる。この場合、光学プリズムもしくは光学ミラーの反射面の傾きを微調整する微動アクチュエータを設けるのが好ましい。これにより、光学系の自由度が高くなり、また、微動アクチュエータにより高精度なトラッキング制御か可能となる。

【００１３】スライダーに、再生用の巨大磁気抵抗効果もしくは磁気抵抗効果を有する素子を設けても良く、これにより、小型コンパクトで且つ高精度の再生を行うことができる装置を得ることができる。また、スライダーにおける記録媒体に対向する位置にコイル状の導電性配線を設けてもよく、この導電性配線により記録媒体の磁界変調を行わせて、記録のオーバーライトが可能となる。

【００１４】

【発明の実施の形態】以下、本発明の好ましい実施形態について、図面を参照して説明する。本発明に係る光学記録再生装置の第１実施形態を図１に示しており、半導体レーザ１０から波長６５０ｎｍ近傍のレーザ光が固定光学系１１に向かって照射され、固定光学系１１において平行光束となって、可動光学系１２内の第１ミラー１３に照射される。このように照射されたレーザ光は、可動光学系１２内において第１および第２ミラー１３，１４により方向を変えられて対物レンズ１５に導かれ、半球状のシリコンカーバイド（ＳｉＣ）を材料とする固体浸レンズ１６に向かって集光する光となり、固体浸レンズ１６のレンズ底面にスポットを形成する。固体浸レンズ１６の底面は光磁気ディスク（光学記録媒体）１の表面１ａに近接配設され、光磁気ディスク１の表面１ａは固体浸レンズ１６のレンズ底面の近接場領域まで近づいており、固体浸レンズ１６の透過光と浸み出し光（エバネッセント光）を使って記録面１ａに集光スポットを形成する。

【００１５】この装置による情報の記録再生に際しては、光磁気ディスク１を回転軸１ｂを中心として水平面

内で高速回転させた状態で、可動光学系１２により固体浸レンズ１６を半径方向に走査移動させ、対物レンズ１５と制御系１７によってフォーカスサーボを加えつつ、光磁気ディスク１の表面１ａに形成した集光スポットにより高密度の光学的な情報の記録再生を行う。

【００１６】ここで固体浸レンズ１６の材料であるシリコンカーバイドの屈折率は、波長約６５０ｎｍのレーザ光において２．６３である。このため、上記のように波長６５０ｎｍのレーザ光を射出する半導体レーザ１０とシリコンカーバイド製の固体浸レンズ１６との組み合わせにより、屈折率１．５程度であるガラス材料により固体浸レンズを構成した場合に比べ、集光スポット径を５７％の大きさとすることができ、記録密度を約３倍とすることができる。

【００１７】なお、上記実施形態においては、波長６５０ｎｍのレーザ光とシリコンカーバイド製の固体浸レンズとを用いたが、これ以外の組み合わせも可能であり、例えば次表１に示すような組み合わせでも良い。

【００１８】

【表１】

材料	屈折率（ｎ）	波長（λ）
ダイヤモンド	２．４１	６５０ｎｍ
チタン酸ストロンチウム	２．４	６５０ｎｍ
ルチル	２．６	６５０ｎｍ
ガリウム燐	３．３	６５０ｎｍ
硫化亜鉛	２．３７	６５０ｎｍ
硫化砒素	２．５	６５０ｎｍ
ニオブ酸リチウム	２．２８	６５０ｎｍ
酸化ジルコニウム	２．２	６５０ｎｍ
窒化シリコン	２．０１	６５０ｎｍ

【００１９】次に、本発明に係る光学記録再生装置の第２実施形態について図２および図３を参照して説明する。この装置は、スピンドルモータ２により回転軸１ｂを中心として回転駆動される光磁気ディスク１の上面記録面１ａの上に近接して位置する情報記録再生ヘッド２０と、この情報記録再生ヘッド２０を保持するヘッドアーム装置３０とを有して構成される。

【００２０】情報記録再生ヘッド２０はスライダー２１を備えており、スライダー２１は回転する光磁気ディスク１の上面記録面１ａの上に位置し、空気ベアリング効果により上面記録面１ａから一定微小距離だけ浮上した状態となる（すなわち、フライングヘッドを構成する）。ヘッドアーム装置３０は、ボイスコイルモータ３１に繋がれて回転駆動される回転軸３２と、この回転軸３２の上端から水平に延びたアーム部３３と、アーム部３３の中間部下面において情報記録再生ヘッド２０を上下の移動を許容するようにして支持するサスペンション部３４とから構成される。ボイスコイルモータ３１により回転軸３２が回転駆動されるとアーム部３３が水平に揺動移動され、情報記録再生ヘッド２０を光磁気ディスク１の回転方向に対してほぼ直角方向（半径方向）に移動させて情報記録再生ヘッド２０が光磁気ディスク１の上面記録面１ａ上で走査される。すなわちトラッキング制御が行われる。

【００２１】情報記録再生ヘッド２０において、スライダー２１に上方に広がる円形テーパ状の空隙２１ａが形成され、空隙２１ａ内にはチタン酸ストロンチウム（$SrTiO_3$）から作られた固体浸レンズ２２が配設され、上部には対物レンズ２３が配設されている。ここでヘッドアーム装置３０のアーム部３３は、対物レンズ２※３と上下に対向する位置まで延びており、その先端部は４５°傾斜した反射面３５を有するするとともにこの反射面３５には高反射膜が設けられている。なお、空隙２１ａを透明もしくは光透過性を有する材料で充満させても良い。

【００２２】アーム部３３は中空もしくは透明材料から形成されており、その内部を記録用レーザ光が鎖線で示すように透過可能である。図示しない記録光照射装置（レーザ光源）から波長６５０ｎｍの記録用レーザ光がアーム部３３を通って鎖線のように照射されるようになっており、このレーザ光は高反射膜を有した反射面３５において反射された後、対物レンズ２３により収束されて固体浸レンズ２２に入射され、光磁気ディスク１の上面記録面１ａに集光スポットを形成する。

【００２３】以上の構成の情報記録再生装置の動作を説明する。まず光磁気ディスク１をスピンドルモータ２により所定の速度で回転させ、ヘッドアーム装置３０のサスペンション部３４に支持されてディスク１の上面記録面１ａ上に配置された情報記録再生ヘッド２０を、空気ベアリング効果により上面記録面１ａから微小距離だけ浮上した状態とする。この状態で、記録光照射装置から照射された記録用レーザー光は鎖線で示す光路に沿って照射されて反射面３５で反射され、対物レンズ２３により収束されて固体浸レンズ２２に照射され、光磁気ディスク１の上面記録面１ａに集光スポットが形成される。

【００２４】ここで光磁気ディスク１は定速回転で駆動されており、スライダー２１の浮上量は常に一定であり、この浮上量を集光スポットが上面記録面に焦点を結ぶように設定されている。このため、フォーカシング機構を設ける必要はない。また、浮上量は極く微小であ

り、固体浸レンズ22のレンズ底面の近接場領域まで光磁気ディスク1の記録面1aが近づき、固体浸レンズ22の透過光と浸み出し光により集光スポットが形成される。

【0025】このように形成される集光スポット光により情報の記録を行うときには、まず集光スポット部をここに照射されるレーザー光によりキュリー温度以上に加熱し、外部磁場を印加する装置を用いてこの部分の磁性を変化（磁化を反転）させて情報記録を行うのであるが、これについてはすでに周知のことなので、外部磁場を印加する装置は図示せず、その作動説明も省略する。また、情報の再生（読み取り）についても、磁気光学カー効果を検出する装置が用いられるが、これについても図示およびその説明を省略する。

【0026】このような情報記録は、光磁気ディスク1の回転に対応して情報記録再生ヘッド20を光磁気ディスク1の半径方向に移動させて（走査して）行われるが、この情報記録再生ヘッド20の走査すなわちトラッキングは、ヘッドアーム装置30のボイスコイルモータ31により回転軸32を中心としてアーム部33を回動させて行われる。なお、この回動をリニア型アクチュエータによってもよい。

【0027】この第2実施形態の場合には、固体浸レンズ22をチタン酸ストロンチウムから作り、記録光照射装置から波長650nmの記録用レーザ光を照射して集光スポットを形成するようになっており、このときの固体浸レンズ22の屈折率n＝2．4である。このため、ガラス材料製の固体浸レンズを用いる場合より小さな集光スポットを形成して、高密度記録再生が可能である。

【0028】次に、本発明に係る光学記録再生装置の第3実施形態について図4を参照して説明する。この装置は、スピンドルモータ2により回転軸1bを中心として回転駆動される光磁気ディスク1の上面記録面1aの上に近接して位置する情報記録再生ヘッド40と、この情報記録再生ヘッド40を保持するヘッドアーム装置50とを有して構成される。

【0029】情報記録再生ヘッド40はスライダー41を備えており、スライダー41は回転する光磁気ディスク1の上面記録面1aの上に位置し、空気ベアリング効果により上面記録面1aから一定微小距離だけ浮上した状態となる。ヘッドアーム装置50は、ボイスコイルモータ51に繋がれて回転駆動される回転軸52と、この回転軸52の上端から水平に延びたアーム部53と、アーム部53の先端部において情報記録再生ヘッド40を上下の移動を許容するようにして支持するサスペンション部54とから構成される。ボイスコイルモータ51によりアーム部53が水平に揺動移動され、情報記録再生ヘッド40を光磁気ディスク1の回転方向に対してほぼ直角方向（半径方向）に移動させて情報記録再生ヘッド40の光磁気ディスク1の上面記録面1a上におけるトラッキング制御が行われる。

【0030】情報記録再生ヘッド40において、スライダー41に上方に広がる円形テーパ状の空隙41aが形成され、空隙41a内にはシリコンカーバイド（SiC）から作られた固体浸レンズ42が配設され、上部には対物レンズ43が配設されている。さらに、スペーサ44を介してマイクロプリズム45が対物レンズ43の上方に位置して配設されている。なお、マイクロプリズム45は高反射膜が設けられた反射面46を有する。この場合においても、空隙41aを透明もしくは光透過性を有する材料で充満させても良い。

【0031】この装置では、図示しない記録光照射装置（レーザ光源）から波長650nmの記録用レーザ光がマイクロプリズム45の反射面46に向かって鎖線のように照射されるようになっており、このレーザ光は反射面46において反射された後、対物レンズ43により収束されて固体浸レンズ42に入射され、光磁気ディスク1の上面記録面1aに集光スポットを形成する。

【0032】以上の構成の情報記録再生装置の動作は、図2及び図3に示した第2実施形態の場合とほぼ同一なのでその説明は省略する。この第3実施形態の場合には、固体浸レンズ42をシリコンカーバイド（SiC）から作り、記録光照射装置から波長650nmの記録用レーザ光を照射して集光スポットを形成するようになっており、このときの固体浸レンズ42の屈折率n＝2．63である。このため、ガラス材料製の固体浸レンズを用いる場合より小さな集光スポットを形成して、高密度記録再生が可能である。

【0033】次に、本発明に係る光学記録再生装置の第4実施形態について図5を参照して説明する。この装置は、微動マイクロミラー64を有した情報記録再生ヘッド60と、この情報記録再生ヘッド60を保持するヘッドアーム装置70とを有して構成される。

【0034】情報記録再生ヘッド60は、空気ベアリングにより回転する光磁気ディスク1の上面記録面1aの上で浮上するスライダー61と、このスライダー61の上に図示のように配設された固体浸レンズ62、対物レンズ63および微動マイクロミラー64から構成される。なお、微動マイクロミラー64は、反射ミラー面65の傾斜を微調整可能なアクチュエータ66を有する。ヘッドアーム装置70は、ボイスコイルモータ71により回転駆動される回転軸72と、この回転軸72に繋がるアーム部73と、アーム部73の先端部において情報記録再生ヘッド60を支持するサスペンション部74とから構成される。

【0035】ボイスコイルモータ71によりアーム部73が水平に揺動移動され、情報記録再生ヘッド60を光磁気ディスク1の回転方向に対してほぼ直角方向（半径方向）に移動させて情報記録再生ヘッド60の光磁気ディスク1の上面記録面1a上におけるトラッキング制御

が行われるが、このとき微動マイクロミラー64においてアクチュエータ66により反射ミラー面65の傾斜を微調整して、微小トラッキング制御を行い、極めて高精度でのトラッキング制御を行うことができるようになっている。

【0036】この装置では、図示しない記録光照射装置（レーザ光源）から波長650nmの記録用レーザ光が微動マイクロミラー64の反射ミラー面65に向かって鎖線のように照射され、反射ミラー面65において反射された後、対物レンズ63により収束されて固体浸レンズ62に入射され、光磁気ディスク1の上面記録面1aに集光スポットを形成する。この装置では、固体浸レンズ62をシリコンカーバイド（SiC）から作り、記録光照射装置から波長650nmの記録用レーザ光を照射して集光スポットを形成するようになっており、このときの固体浸レンズ62の屈折率n＝2．63である。このため、小さな集光スポットを形成して、高密度記録再生が可能である。

【0037】次に、本発明に係る光学記録再生装置の第5実施形態について図6を参照して説明する。この装置において、情報記録再生ヘッド80は、空気ベアリングにより回転する光磁気ディスク1の上面記録面1aの上で浮上するスライダー81と、このスライダー81の上に図示のように配設された固体浸レンズ82、対物レンズ83およびマイクロミラー84から構成される。なお、スライダー81の底面に、固体浸レンズ82を囲むようにして、コイル状の導電性配線87を備えたマイクロコイル86（図7参照）が埋め込まれている。この導電性配線87に通電することにより、光磁気ディスク1の記録面1aにおけるマイクロコイル86が対向する部分の磁界変調を行い、記録のオーバーライトを行うことが可能となっている。

【0038】ヘッドアーム装置90は、ボイスコイルモータ91により回転駆動される回転軸92と、この回転軸92に繋がるアーム部93と、アーム部93の先端部において微動アクチュエータ100を介して情報記録再生ヘッド80を支持するサスペンション部94とから構成される。微動アクチュエータ100の構成を図8に示しており、アーム部93に繋がれた固定ブロック101と、サスペンション部94に繋がれた可動ブロック102との間に積層型圧電素子103を配設して構成される。圧電素子103への通電制御を行うことにより、固定ブロック101に対して可動ブロック102を矢印方向に微小移動させることができる。なお、微動アクチュエータを、圧電型のものに代えて、電磁力や静電力を用いたタイプのものから構成しても良い。

【0039】ボイスコイルモータ91によりアーム部93が水平に揺動移動され、情報記録再生ヘッド80を光磁気ディスク1の回転方向に対してほぼ直角方向（半径方向）に移動させて情報記録再生ヘッド80の光磁気ディスク1の上面記録面1a上におけるトラッキング制御が行われる。このとき、微動アクチュエータ100により情報記録再生ヘッド80の微小トラッキング制御を行い、極めて高精度でのトラッキング制御を行うことができる。

【0040】この装置では、図示しない記録光照射装置（レーザ光源）から波長650nmの記録用レーザ光がマイクロミラー84の反射ミラー面85に向かって鎖線のように照射され、反射ミラー面85において反射された後、対物レンズ83により収束されて固体浸レンズ82に入射され、光磁気ディスク1の上面記録面1aに集光スポットを形成する。この装置では、固体浸レンズ82をシリコンカーバイド（SiC）から作り、記録光照射装置から波長650nmの記録用レーザ光を照射して集光スポットを形成するようになっており、このときの固体浸レンズ82の屈折率n＝2．63である。このため、小さな集光スポットを形成して、高密度記録再生が可能である。

【0041】次に、本発明に係る光学記録再生装置の第6実施形態について図9を参照して説明する。この装置において、情報記録再生ヘッド110は、空気ベアリングにより回転する光磁気ディスク1の上面記録面1aの上で浮上するスライダー111と、このスライダー111の上に図示のように配設された固体浸レンズ112、対物レンズ113およびマイクロミラー114から構成される。なお、スライダー111の底面に、第5実施形態と同様に図7に示すようなマイクロコイル86が埋め込まれている。これにより、光磁気ディスク1の記録面1aにおけるマイクロコイル86が対向する部分の磁界変調を行い、記録のオーバーライトを行うことが可能である。

【0042】スライダー111の先端には、光磁気ディスク1に記録された情報の再生に用いられる巨大磁気抵抗効果素子（GMR素子）130が再生ヘッドとして取り付けられている。この巨大磁気抵抗効果素子20を図10～図12を参照して説明する。

【0043】図10に磁気抵抗効果素子130のみを取り出して拡大表示しており、この素子130の断面を示す図11および図12から良く分かるように、四層構造のGMRセンサ137とこの上に設けられた二つの電極138，139とを上下の磁気シールド131，132により覆って構成される。GMRセンサ137は、反強磁性膜133と、第1磁性膜134と、非磁性膜135と、第2強磁性膜136とを図示のように四層に重ねて形成され、いわゆるスピンバルブ構造となっている。なお、反強磁性膜133にはFeMnを用い、第1および第2磁性膜134，136にはNiFeを用い、非磁性膜135にはCuを用いた。

【0044】ヘッドアーム装置120は、ボイスコイルモータ121により回転駆動される回転軸122と、こ

の回転軸122に繋がるアーム部123と、アーム部123の先端部において情報記録再生ヘッド110を支持するサスペンション部124とから構成される。ボイスコイルモータ121によりアーム部123が水平に揺動移動され、情報記録再生ヘッド110を光磁気ディスク1の回転方向に対してほぼ直角方向（半径方向）に移動させて情報記録再生ヘッド110の光磁気ディスク1の上面記録面1a上におけるトラッキング制御が行われる。

【0045】この装置では、図示しない記録光照射装置（レーザ光源）から波長650nmの記録用レーザ光がマイクロミラー114の反射ミラー面115に向かって鎖線のように照射され、反射ミラー面115において反射された後、対物レンズ113により収束されて固体浸レンズ112に入射され、光磁気ディスク1の上面記録面1aに集光スポットを形成する。この装置では、固体浸レンズ112をシリコンカーバイド（SiC）から作り、記録光照射装置から波長650nmの記録用レーザ光を照射して集光スポットを形成するようになっており、このときの固体浸レンズ82の屈折率n＝2．63である。このため、小さな集光スポットを形成して、高密度記録再生が可能である。

【0046】このように形成される集光スポット光により情報の記録を行うときには、まず集光スポット部をここに照射されるレーザー光によりキュリー温度以上に加熱し、図示しない外部磁場を印加する装置を用いてこの部分の磁性を変化（磁化を反転）させて情報記録を行う。一方、このようにして光磁気ディスク2に記録された情報の再生は、巨大磁気抵抗効果素子130により行われる。この再生は、二つの電極138，139間に電圧を印可して図に矢印Cで示すようなセンス電流をGMRセンサ137に流した状態で行われ、光磁気ディスク1からの磁界によりGMRセンサ137の磁化が回転してその電気抵抗が変化するという磁気抵抗効果を利用して行われる。

【0047】GMRセンサ137の電気抵抗変化は、具体的には次のように起こる。第1磁性膜134は反強磁性膜133と接しているので第1磁性膜134の磁化は固定されている。これに対し、第2磁性膜136の磁化は媒体（光磁気ディスク）からの外部磁界により回転される。このため、外部磁界を受けると、第1および第2磁性膜134，136の磁化の向きが平行から反平行へ変化する。ここで、これら二つの磁性膜134，136の磁化方向が同じ（平行である）場合には流れ込む電子の磁気的散乱は小さく電気抵抗は小さくなる。一方、磁性膜134，136の磁化方向が異なる（反平行である）場合には流れ込む電子の磁気的散乱が大きくなり電気抵抗も大きくなる。このように、巨大磁気抵抗効果素子130を用いれば、信号対雑音比を向上させて情報の再生が可能となる。

【0048】

【発明の効果】以上説明したように、本発明によれば、固体浸レンズの材料とこの固体浸レンズにより集光されるレーザ光とを適宜選択し、屈折率が2．0以上となる条件の組み合わせの下で固体浸レンズおよびレーザ光を使用するため、固体浸レンズを大きな屈折率で使用し、集光スポットを小さくして高密度での情報の記録再生が可能となる。

【0049】なお、平面運動する記録媒体の記録面に置かれて空気ベアリングによりこの記録面から浮上して位置するスライダーを用いて光学記録再生装置を構成し、スライダーに固体浸レンズを配設し、走査駆動機構によりスライダーを走査移動するように構成するのが好ましい。このようにすれば、スライダーが空気ベアリングにより常に一定の距離を保って記録面から浮上するため、レンズのフォーカス機構が不要となる。また、スライダーにレーザ光源からのレーザ光束を導くための、光学ミラー、光学プリズム、対物レンズ等を設けることができ、装置構成を簡単にすることができる。

【0050】また、走査駆動機構に、スライダーを走査移動方向と同方向に微小移動させる微動アクチュエータを設けたり、光学プリズムもしくは光学ミラーの反射面の傾きを微調整する微動アクチュエータを設けるのが好ましい。これにより、光学系の自由度が高くなり、また、微動アクチュエータにより高精度なトラッキング制御が可能となる。

【0051】スライダーに、再生用の巨大磁気抵抗効果もしくは磁気抵抗効果を有する素子を設けても良く、これにより、小型コンパクトで且つ高精度の再生を行うことができる装置を得ることができる。また、スライダーにおける記録媒体に対向する位置にコイル状の導電性配線を設けてもよく、この導電性配線により記録媒体の磁界変調を行わせて、記録のオーバーライトが可能となる。

【図面の簡単な説明】

【図1】本発明の第1実施形態に係る光学記録再生装置を示す概略斜視図である。

【図2】本発明の第2実施形態に係る光学記録再生装置を示す概略斜視図である。

【図3】本発明の第2実施形態に係る光学記録再生装置を示すための図2における矢印III-IIIに沿った正面断面図である。

【図4】本発明の第3実施形態に係る光学記録再生装置を示す正面断面図である。

【図5】本発明の第4実施形態に係る光学記録再生装置を示す正面断面図である。

【図6】本発明の第5実施形態に係る光学記録再生装置を示す正面断面図である。

【図7】本発明の第5実施形態に係る光学記録再生装置に用いられる導電性配線の構成を示す底面図である。

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【図8】本発明の第5実施形態に係る光学記録再生装置を構成する微動アクチュエータを示す斜視図である。

【図9】本発明の第6実施形態に係る光学記録再生装置を示す正面断面図である。

【図10】本発明の第6実施形態に係る光学記録再生装置に用いられる巨大磁気抵抗効果素子を示す斜視図である。

【図11】この巨大磁気抵抗効果素子を示す図10の矢印X－Xに沿った断面図である。

【図12】この巨大磁気抵抗効果素子を示す図10の矢印XI－XIに沿った断面図である。

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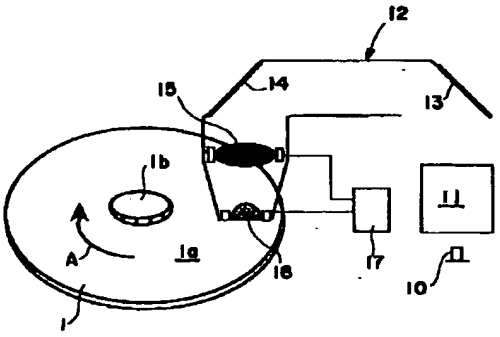
【図13】従来の光学記録再生装置を示す斜視図である。

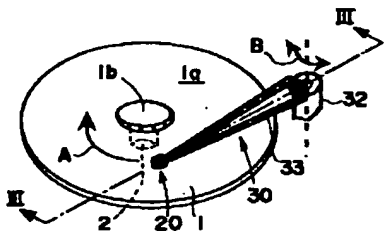
【符号の説明】

1　光磁気ディスク
2　スピンドルモータ
11　固定光学系
12　可動光学系
15　対物レンズ
16　固体浸レンズ
20，40，60，80，110　情報記録再生ヘッド
30，50，70，90，120　ヘッドアーム装置

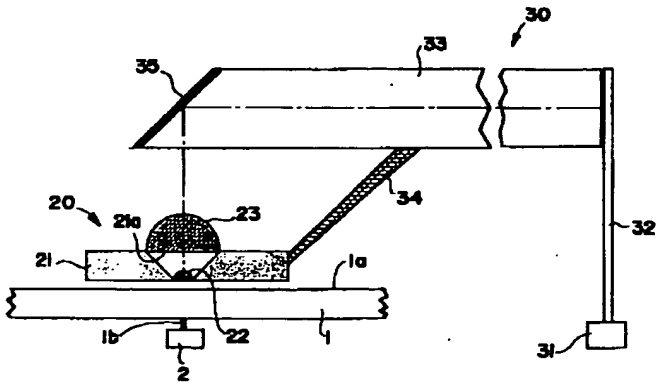
【図1】



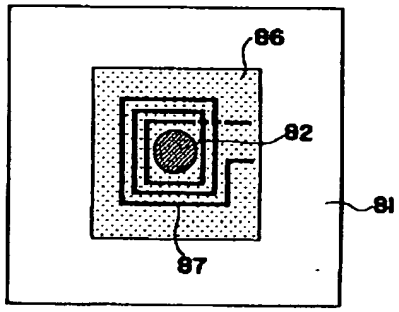
【図2】



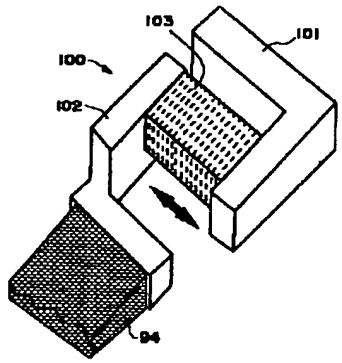
【図3】



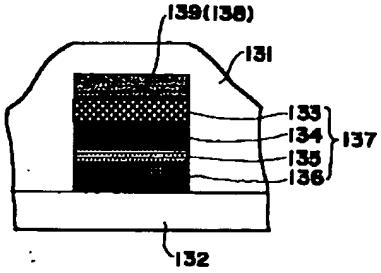
【図7】



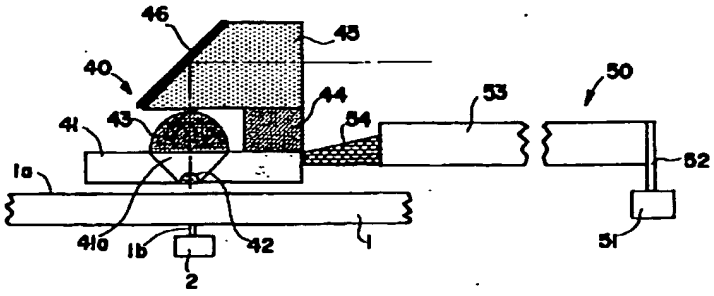
【図8】



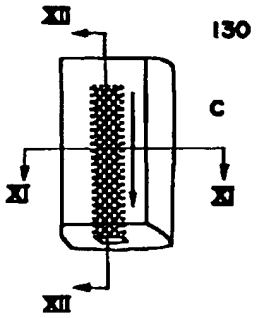
【図11】



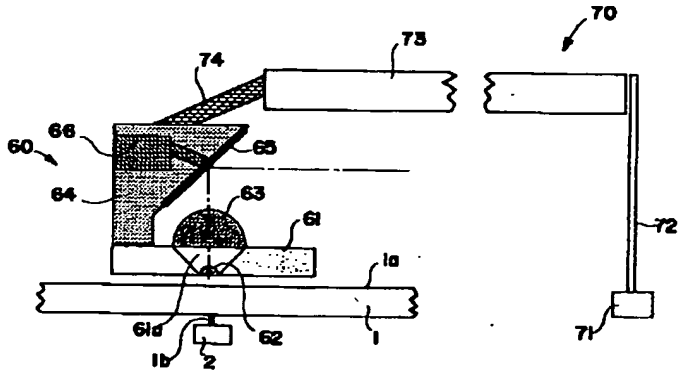
【図4】



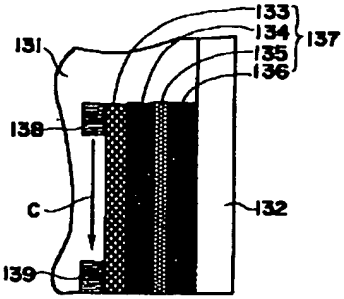
【図10】



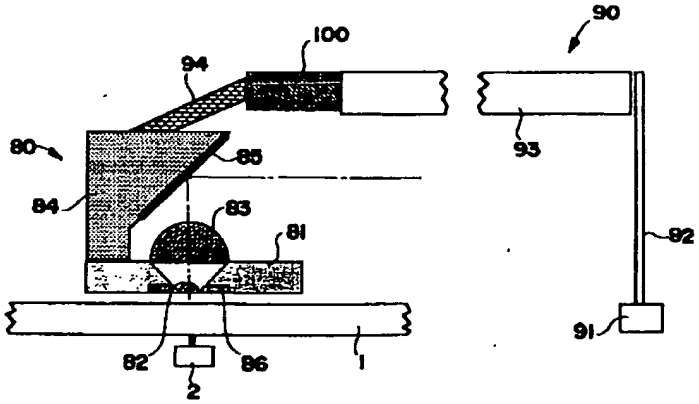
【図5】



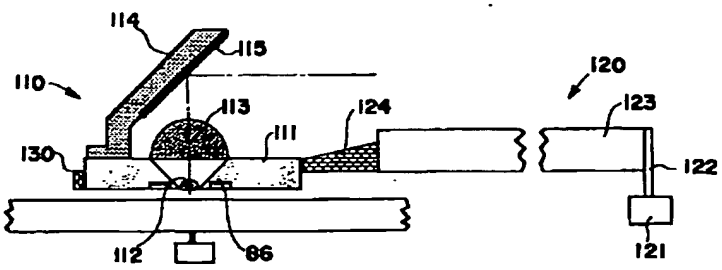
【図12】



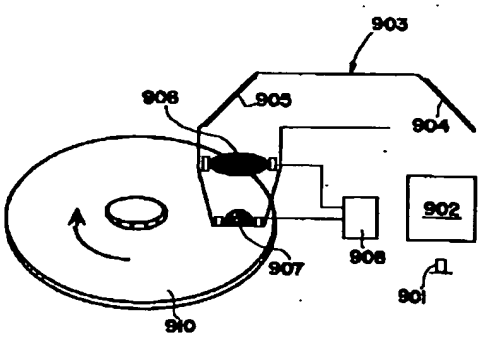
【図6】



【図9】



【図13】



フロントページの続き

(51)Int.Cl.[6]	識別記号	FI	
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